Infographic: Impact of implant materials and malalignment in unicompartmental knee arthroplasty

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INFOGRAPHIC

Impact of implant materials and malalignment in unicompartmental knee arthroplasty

Keywords: Unicompartmental knee arthroplasty, Malalignment, Bone strain, Finite element analysis

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Unicompartmental knee arthroplasty (UKA) survival remains variable across implants and institutions. A strong relationship has been proven between UKA survival and surgeon volume,[1] implying that achieving well-aligned UKAs is important for maximizing survival. In nearly half of UKA revisions, the indication for revision is unexplained pain,[2] and elevated proximal tibial strain and microdamage are thought to contribute to this.[3,4]

A finite element model of a composite tibia (experimentally validated using digital image correlation and acoustic emission[5]) was used to investigate the effect of tibial component alignment in cemented metal-backed (MB) and cemented all-polyethylene (AP) fixed-bearing medial UKAs.[6] A linearly elastic analysis was performed with loads up to 2500 N medially (4170 N total load). Standard alignment (medial proximal tibial angle 90°, 6° posterior slope), coronal malalignment (3°, 5°, 10° varus; 3°, 5° valgus), and sagittal malalignment (0°, 3°, 6°, 9°, 12°) were analyzed. The primary outcome measure was the volume of compressively overstrained cancellous bone (VOCB) < -3000 με. The secondary outcome measure was maximum cortical bone stress (MCBS) over a medial region of interest.

Malalignment had less effect on the VOCB than implant selection. Well-aligned AP implants displayed greater volumes of overstrained cancellous bone and greater anteromedial MCBS than poorly aligned MB implants at both low and high loads. Consistent with previous studies of MB implants,[7] varus malalignment increased MCBS but decreased VOCB in both implants. Varus malalignment of 10° reduced the VOCB by 10% and 3% in AP and MB implants, respectively, but increased the MCBS by 14% and 13%. Valgus malalignment of 5° increased the VOCB by 8% and 4% in AP and MB implants, respectively, with reductions in MCBS of 7% and 10%. Sagittal malalignment displayed negligible effects.

Supportive of previous work showing AP implants to be more sensitive to polyethylene thickness than MB implants,[8] this finite element study has shown that UKA tibial component material has a greater effect on proximal tibial bone strain than malalignment. Cancellous bone strain and cortical bone stress had a reciprocal relationship: varus malalignment reduced cancellous bone strain but increased anteromedial cortical bone stress; valgus malalignment did the reverse. Well-aligned AP implants display greater bone strains than malaligned MB implants.

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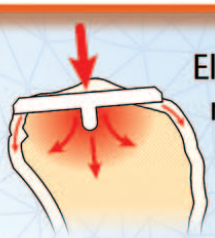
Bone & Joint Research Infographics

Impact of implant materials & malalignment in unicompartmental knee arthroplasty

I. Danese et al., researchers from University of Edinburgh, Bone Joint Res 2019

Up to 48% of revisions for unicompartmental knee arthroplasties (UKAs) are due to unexplained pain



Elevated strain and microdamage from malalignment may contribute to pain

Study Design

Tibial strain from malalignment was modelled using **finite element analysis (FEA)** for:

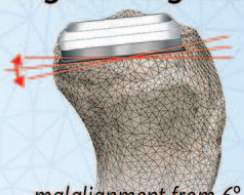
all-polyethylene (AP) UKAs | metal-backed (MB) UKAs

Outcome measures:

- volume of compressively overstrained cancellous bone (VOCB)
- maximum von Mises stress in cortical bone (MSCB)

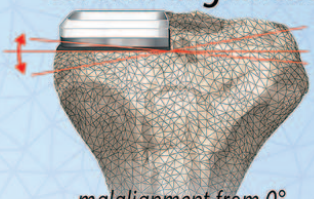
Researchers examined both:

Sagittal alignment



malalignment from 6° (to 0°, 3°, 9° & 12°)

Coronal alignment



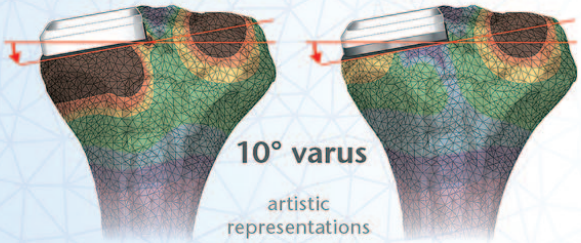
malalignment from 0° (3°, 5°, 10° varus & 3°, 5° valgus)

Results

Coronal plane malalignment impacts bone strain

AP UKA

MB UKA



10° varus

artistic representations

In comparison, changes in strain were negligible for sagittal plane malalignments

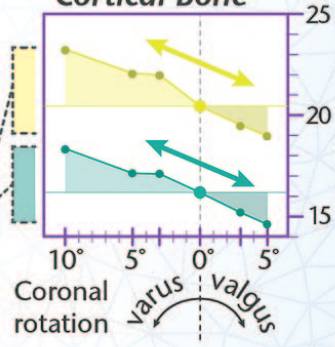
Reciprocal relationship in strain of cortical & cancellous bone

Most important factor

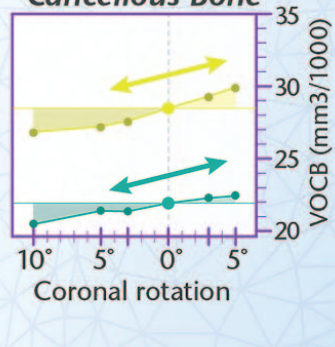
Material of UKA has greatest impact on bone strain

Range of strain for AP UKAs is *greater than* largest MB value

Cortical Bone



Cancellous Bone



Conclusions

All-polyethylene implants translate greater strain to underlying bone and are more sensitive to coronal plane malalignments than metal-backed UKAs.

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Infographic by Ryan Lewis & Iain Murray

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